

January 1995

LM140A/LM140/LM340A/LM340/LM7800C Series 3-Terminal Positive Regulators

General Description

The LM140A/LM140/LM340A/LM340/LM7800C monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Considerable effort was expended to make the entire series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

The 5V, 12V, and 15V regulator options are available in the steel TO-3 power package. The LM340A/LM340/LM7800C series is available in the TO-220 plastic power package, and the LM7805 and LM7812 are also available in the surface-mount TO-263 package.

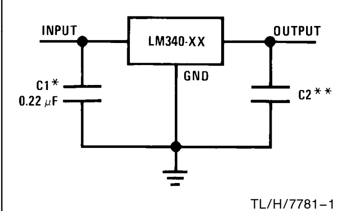
Features

- Complete specifications at 1A load
- Output voltage tolerances of $\pm 2\%$ at $T_j = 25°C$ and $\pm 4\%$ over the temperature range (LM140A/LM340A)
- Line regulation of 0.01% of V_{OUT}/V of ΔV_{IN} at 1A load (LM140A/LM340A)
- Load regulation of 0.3% of V_{OUT}/A (LM140A/LM340A)
- Internal thermal overload protection
- Internal short-circuit current limit
- Output transistor safe area protection
- P^+ Product Enhancement tested

Device	Output Voltages	Packages
LM140A/LM140	5, 12, 15	TO-3 (K)
LM340A/LM340	5, 12, 15	TO-3 (K), TO-220 (T)
LM7800C	5, 6, 8, 12, 15, 18, 24	TO-220 (T), TO-263 (S) (5V and 12V only)

Typical Applications

Fixed Output Regulator

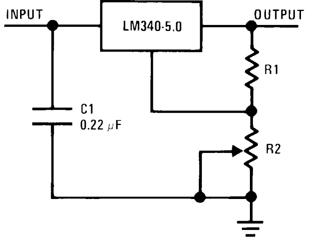


TL/H/7781–1

*Required if the regulator is located far from the power supply filter.

**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1 μF, ceramic disc).

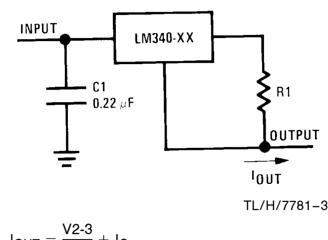
Adjustable Output Regulator



TL/H/7781–2

$V_{OUT} = 5V + (5V/R1 + I_Q)$ R2 $5V/R1 > 3 I_Q$, load regulation $(L_r) \approx [(R1 + R2)/R1]$ (L_r of LM340-5).

Current Regulator



TL/H/7781–3

$$I_{OUT} = \frac{V2\text{-}3}{R1} + I_Q$$

$\Delta I_Q = 1.3$ mA over line and load changes.

RRD-B30M115/Printed in U. S. A.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 5)

DC Input Voltage	
All Devices except LM7824/LM7824C	35V
LM7824/LM7824C	40V
Internal Power Dissipation (Note 2)	Internally Limited
Maximum Junction Temperature	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package (K)	300°C
TO-220 Package (T), TO-263 Package (S)	230°C
ESD Susceptibility (Note 3)	2 kV

Operating Conditions (Note 1)

Temperature Range (T_A) (Note 2)	
LM140A, LM140	−55°C to +125°C
LM340A, LM340, LM7805C, LM7812C, LM7815C	0°C to +70°C
LM7806C, LM7808C, LM7818C, LM7824C	0°C to +125°C

LM140A/LM340A

Electrical Characteristics

I_{OUT} = 1A, −55°C ≤ T_J ≤ +150°C (LM140A), or 0°C ≤ T_J ≤ + 125°C (LM340A) unless otherwise specified (Note 4)

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	T_J = 25°C	4.9	5	5.1	11.75	12	12.25	14.7	15	15.3	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A V_{MIN} ≤ V_{IN} ≤ V_{MAX}	4.8 (7.5 ≤ V_{IN} ≤ 20)		5.2	11.5 (14.8 ≤ V_{IN} ≤ 27)		12.5	14.4 (17.9 ≤ V_{IN} ≤ 30)		15.6	V V
ΔV_O	Line Regulation	I_O = 500 mA ΔV_{IN}	 (7.5 ≤ V_{IN} ≤ 20)		10	 (14.8 ≤ V_{IN} ≤ 27)		18	 (17.9 ≤ V_{IN} ≤ 30)		22	mV V
		T_J = 25°C ΔV_{IN}	 (7.5 ≤ V_{IN} ≤ 20)	3	10	 (14.5 ≤ V_{IN} ≤ 27)	4	18	 (17.5 ≤ V_{IN} ≤ 30)	4	22	mV V
		T_J = 25°C Over Temperature ΔV_{IN}	 (8 ≤ V_{IN} ≤ 12)		4 12	 (16 ≤ V_{IN} ≤ 22)		9 30	 (20 ≤ V_{IN} ≤ 26)		10 30	mV mV V
ΔV_O	Load Regulation	T_J = 25°C, 5 mA ≤ I_O ≤ 1.5A T_J = 25°C, 250 mA ≤ I_O ≤ 750 mA		10	25 15		12	32 19		12	35 21	mV mV
		Over Temperature, 5 mA ≤ I_O ≤ 1A			25			60			75	mV
I_Q	Quiescent Current	T_J = 25°C Over Temperature			6 6.5			6 6.5			6 6.5	mA mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A			0.5			0.5			0.5	mA
		T_J = 25°C, I_O = 1A V_{MIN} ≤ V_{IN} ≤ V_{MAX}	 (7.5 ≤ V_{IN} ≤ 20)		0.8	 (14.8 ≤ V_{IN} ≤ 27)		0.8	 (17.9 ≤ V_{IN} ≤ 30)		0.8	mA V
		I_O = 500 mA V_{MIN} ≤ V_{IN} ≤ V_{MAX}	 (8 ≤ V_{IN} ≤ 25)		0.8	 (15 ≤ V_{IN} ≤ 30)		0.8	 (17.9 ≤ V_{IN} ≤ 30)		0.8	mA V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz		40			75			90		µV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	T_J = 25°C, f = 120 Hz, I_O = 1A or f = 120 Hz, I_O = 500 mA, Over Temperature, V_{MIN} ≤ V_{IN} ≤ V_{MAX}	68 68 (8 ≤ V_{IN} ≤ 18)	80		61 61 (15 ≤ V_{IN} ≤ 25)	72		60 60 (18.5 ≤ V_{IN} ≤ 28.5)	70		dB dB V
R_O	Dropout Voltage Output Resistance Short-Circuit Current Peak Output Current Average TC of V_O	T_J = 25°C, I_O = 1A f = 1 kHz T_J = 25°C T_J = 25°C Min, T_J = 0°C, I_O = 5 mA		2.0 8 2.1 2.4 −0.6			2.0 18 1.5 2.4 −1.5			2.0 19 1.2 2.4 −1.8		V mΩ A A mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C	7.5			14.5			17.5			V

LM140

Electrical Characteristics (Note 4) $-55°C \leq T_J \leq +150°C$ unless otherwise specified

Symbol	Output Voltage			5V			12V			15V			Units
	Input Voltage (unless otherwise noted)			10V			19V			23V			
	Parameter	Conditions		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	$T_J = 25°C$, 5 mA $\leq I_O \leq$ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		$P_D \leq$ 15W, 5 mA $\leq I_O \leq$ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$			$(8 \leq V_{IN} \leq 20)$			$(15.5 \leq V_{IN} \leq 27)$			$(18.5 \leq V_{IN} \leq 30)$		V
ΔV_O	Line Regulation	I_O = 500 mA	$T_J = 25°C$		3	50		4	120		4	150	mV
			ΔV_{IN}		$(7 \leq V_{IN} \leq 25)$			$(14.5 \leq V_{IN} \leq 30)$			$(17.5 \leq V_{IN} \leq 30)$		V
			$-55°C \leq T_J \leq +150°C$			50			120			150	mV
			ΔV_{IN}		$(8 \leq V_{IN} \leq 20)$			$(15 \leq V_{IN} \leq 27)$			$(18.5 \leq V_{IN} \leq 30)$		V
		$I_O \leq$ 1A	$T_J = 25°C$			50			120			150	mV
			ΔV_{IN}		$(7.5 \leq V_{IN} \leq 20)$			$(14.6 \leq V_{IN} \leq 27)$			$(17.7 \leq V_{IN} \leq 30)$		V
			$-55°C \leq T_J \leq +150°C$			25			60			75	mV
			ΔV_{IN}		$(8 \leq V_{IN} \leq 12)$			$(16 \leq V_{IN} \leq 22)$			$(20 \leq V_{IN} \leq 26)$		V
ΔV_O	Load Regulation	$T_J = 25°C$	5 mA $\leq I_O \leq$ 1.5A		10	50		12	120		12	150	mV
			250 mA $\leq I_P \leq$ 750 mA			25			60			75	mV
		$-55°C \leq T_J \leq +150°C$, 5 mA $\leq I_O \leq$ 1A				50			120			150	mV
I_Q	Quiescent Current	$I_O \leq$ 1A	$T_J = 25°C$			6			6			6	mA
			$-55°C \leq T_J \leq +150°C$			7			7			7	mA
ΔI_Q	Quiescent Current Change	5 mA $\leq I_O \leq$ 1A				0.5			0.5			0.5	mA
		$T_J = 25°C$, $I_O \leq$ 1A				0.8			0.8			0.8	mA
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$			$(8 \leq V_{IN} \leq 20)$			$(15 \leq V_{IN} \leq 27)$			$(18.5 \leq V_{IN} \leq 30)$		V
		I_O = 500 mA, $-55°C \leq T_J \leq +150°C$				0.8			0.8			0.8	mA
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$			$(8 \leq V_{IN} \leq 25)$			$(15 \leq V_{IN} \leq 30)$			$(18.5 \leq V_{IN} \leq 30)$		V
V_N	Output Noise Voltage	$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	$I_O \leq$ 1A, $T_J = 25°C$ or	68	80		61	72		60	70		dB
			$I_O \leq$ 500 mA, $-55°C \leq T_J \leq +150°C$	68			61			60			dB
		$V_{MIN} \leq V_{IN} \leq V_{MAX}$			$(8 \leq V_{IN} \leq 18)$			$(15 \leq V_{IN} \leq 25)$			$(18.5 \leq V_{IN} \leq 28.5)$		V
R_O	Dropout Voltage	$T_J = 25°C$, I_O = 1A			2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz			8			18			19		mΩ
	Short-Circuit Current	$T_J = 25°C$			2.1			1.5			1.2		A
	Peak Output Current	$T_J = 25°C$			2.4			2.4			2.4		A
	Average TC of V_{OUT}	$0°C \leq T_J \leq +150°C$, I_O = 5 mA			−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	$T_J = 25°C$, $I_O \leq$ 1A		7.5			14.6			17.7			V

LM340/LM7800C

Electrical Characteristics (Note 4) 0°C ≤ T_J ≤ +125°C unless otherwise specified

Symbol	Output Voltage			5V			12V			15V			Units
	Input Voltage (unless otherwise noted)			10V			19V			23V			
	Parameter	Conditions		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	T_J = 25°C, 5 mA ≤ I_O ≤ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)			V
ΔV_O	Line Regulation	I_O = 500 mA	T_J = 25°C		3	50		4	120		4	150	mV
			ΔV_{IN}	(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
			0°C ≤ T_J ≤ +125°C			50			120			150	mV
			ΔV_{IN}	(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 1A	T_J = 25°C			50			120			150	mV
			ΔV_{IN}	(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)			V
			0°C ≤ T_J ≤ +125°C			25			60			75	mV
			ΔV_{IN}	(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)			V
ΔV_O	Load Regulation	T_J = 25°C	5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
			250 mA ≤ I_O ≤ 750 mA			25			60			75	mV
		5 mA ≤ I_O ≤ 1A, 0°C ≤ T_J ≤ +125°C				50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A	T_J = 25°C			8			8			8	mA
			0°C ≤ T_J ≤ +125°C			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A				0.5			0.5			0.5	mA
		T_J = 25°C, I_O ≤ 1A				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)			V
		I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)			V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	I_O ≤ 1A, T_J = 25°C	62	80		55	72		54	70		dB
			or I_O ≤ 500 mA, 0°C ≤ T_J ≤ +125°C	62			55			54			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}		(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)			V
R_O	Dropout Voltage	T_J = 25°C, I_O = 1A			2.0			2.0			2.0		V
	Output Resistance	f = 1 kHz			8			18			19		mΩ
	Short-Circuit Current	T_J = 25°C			2.1			1.5			1.2		A
	Peak Output Current	T_J = 25°C			2.4			2.4			2.4		A
	Average TC of V_{OUT}	0°C ≤ T_J ≤ +125°C, I_O = 5 mA			−0.6			−1.5			−1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	T_J = 25°C, I_O ≤ 1A		7.5			14.6			17.7			V

Note 1: Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions see the Electrical Characteristics.

Note 2: The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation (T_{JMAX} = 125°C or 150°C), the junction-to-ambient thermal resistance (θ_{JA}), and the ambient temperature (T_A). $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above T_{JMAX} and the electrical specifications do not apply. If the die temperature rises above 150°C, the device will go into thermal shutdown. For the TO-3 package (K, KC), the junction-to-ambient thermal resistance (θ_{JA}) is 39°C/W. When using a heatsink, θ_{JA} is the sum of the 4°C/W junction-to-case thermal resistance (θ_{JC}) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink. For the TO-220 package (T), θ_{JA} is 54°C/W and θ_{JC} is 4°C/W.

If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package: Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°G/W; and with 1.6 or more inches of copper area, θ_{JA} is 32°C/W.

Note 3: ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

Note 4: All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

Note 5: A military RETS specification is available on request. At the time of printing, the military RETS specifications for the LM140AK-5.0/883, LM140AK-12/883, and LM140AK-15/883 complied with the min and max limits for the respective versions of the LM140A. At the time of printing, the military RETS specifications for the LM140K-5.0/883, LM140K-12/883, and LM140K-15/883 complied with the min and max limits for the respective versions of the LM140. The LM140H/883, LM140K/883, and LM140AK/883 may also be procured as a Standard Military Drawing.

LM7806C
Electrical Characteristics

$0°C \leq T_J \leq +150°C$, $V_I = 11V$, $I_O = 500$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		5.75	6.0	6.25	V
ΔV_O	Line Regulation		$T_J = 25°C$	$8.0V \leq V_I \leq 25V$		5.0	120	mV
				$9.0V \leq V_I \leq 13V$		1.5	60	
ΔV_O	Load Regulation		$T_J = 25°C$	5.0 mA $\leq I_O \leq$ 1.5A		14	120	mV
				250 mA $\leq I_O \leq$ 750 mA		4.0	60	
V_O	Output Voltage		$8.0V \leq V_I \leq 21V$, 5.0 mA $\leq I_O \leq$ 1.0A, $P \leq 15W$		5.7		6.3	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$8.0V \leq V_I \leq 25V$				1.3	mA
		With Load	5.0 mA $\leq I_O \leq$ 1.0A				0.5	
V_N	Noise		$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz			45		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 120 Hz, I_O = 350 mA, $T_J = 25°C$		59	75		dB
V_{DO}	Dropout Voltage		I_O = 1.0A, $T_J = 25°C$			2.0		V
R_O	Output Resistance		f = 1.0 kHz			9		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			550		mA
I_{PK}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		I_O = 5.0 mA, $0°C \leq T_A \leq +125°C$			0.8		mV/°C

LM7808C
Electrical Characteristics

$0°C \leq T_J \leq +150°C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)		LM7808C			Units
					Min	Typ	Max	
V_O	Output Voltage		$T_J = 25°C$		7.7	8.0	8.3	V
ΔV_O	Line Regulation		$T_J = 25°C$	$10.5V \leq V_I \leq 25V$		6.0	160	mV
				$11.0V \leq V_I \leq 17V$		2.0	80	
ΔV_O	Load Regulation		$T_J = 25°C$	5.0 mA $\leq I_O \leq$ 1.5A		12	160	mV
				250 mA $\leq I_O \leq$ 750 mA		4.0	80	
V_O	Output Voltage		$11.5V \leq V_I \leq 23V$, 5.0 mA $\leq I_O \leq$ 1.0A, $P \leq 15W$		7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$11.5V \leq V_I \leq 25V$				1.0	mA
		With Load	5.0 mA $\leq I_O \leq$ 1.0A				0.5	
V_N	Noise		$T_A = 25°C$, 10 Hz $\leq f \leq$ 100 kHz			52		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 120 Hz, I_O = 350 mA, $T_J = 25°C$		56	72		dB
V_{DO}	Dropout Voltage		I_O = 1.0A, $T_J = 25°C$			2.0		V
R_O	Output Resistance		f = 1.0 kHz			16		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.45		A
I_{PK}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		I_O = 5.0 mA			0.8		mV/°C

Note 4: All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM7818C
Electrical Characteristics

$0°C \leq T_J \leq +150°C$, $V_I = 27V$, $I_O = 500$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, unless otherwise specified

Symbol	Parameter		Conditions (Note 4)		LM7818C Min	LM7818C Typ	LM7818C Max	Units
V_O	Output Voltage		$T_J = 25°C$		17.3	18.0	18.7	V
ΔV_O	Line Regulation		$T_J = 25°C$	$21V \leq V_I \leq 33V$		15	360	mV
				$24V \leq V_I \leq 30V$		5.0	180	
ΔV_O	Load Regulation		$T_J = 25°C$	$5.0\ mA \leq I_O \leq 1.5A$		12	360	mV
				$250\ mA \leq I_O \leq 750\ mA$		4.0	180	
V_O	Output Voltage		$22V \leq V_I \leq 33V$, $5.0\ mA \leq I_O \leq 1.0A$, $P \leq 15W$		17.1		18.9	V
I_Q	Quiescent Current		$T_J = 25°C$			4.5	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$22V \leq V_I \leq 33V$				1.0	mA
		With Load	$5.0\ mA \leq I_O \leq 1.0A$				0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \leq f \leq 100\ kHz$			110		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120$ Hz, $I_O = 350$ mA, $T_J = 25°C$		53	69		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		$f = 1.0$ kHz			22		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.20		A
I_{PK}	Peak Output Current		$T_J = 25°C$			2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			1.0		mV/°C

LM7824C
Electrical Characteristics

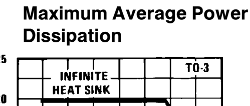
$0°C \leq T_J \leq +150°C$, $V_I = 33V$, $I_O = 500$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, unless otherwise specified

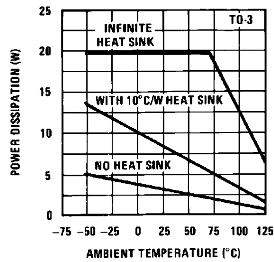
Symbol	Parameter		Conditions (Note 4)		LM7824C Min	LM7824C Typ	LM7824C Max	Units
V_O	Output Voltage		$T_J = 25°C$		23.0	24.0	25.0	V
ΔV_O	Line Regulation		$T_J = 25°C$	$27V \leq V_I \leq 38V$		18	480	mV
				$30V \leq V_I \leq 36V$		6.0	240	
ΔV_O	Load Regulation		$T_J = 25°C$	$5.0\ mA \leq I_O \leq 1.5A$		12	480	mV
				$250\ mA \leq I_O \leq 750\ mA$		4.0	240	
V_O	Output Voltage		$28V \leq V_I \leq 38V$, $5.0\ mA \leq I_O \leq 1.0A$, $P \leq 15W$		22.8		25.2	V
I_Q	Quiescent Current		$T_J = 25°C$			4.6	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$28V \leq V_I \leq 38V$				1.0	mA
		With Load	$5.0\ mA \leq I_O \leq 1.0A$				0.5	
V_N	Noise		$T_A = 25°C$, $10\ Hz \leq f \leq 100\ kHz$			170		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 120$ Hz, $I_O = 350$ mA, $T_J = 25°C$		50	66		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		$f = 1.0$ kHz			28		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.15		A
I_{PK}	Peak Output Current		$T_J = 25°C$			2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			1.5		mV/°C

Note 4: All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

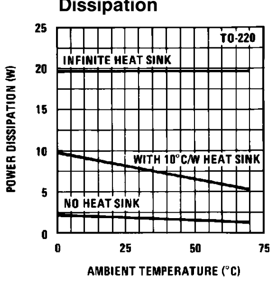
Typical Performance Characteristics

Maximum Average Power Dissipation

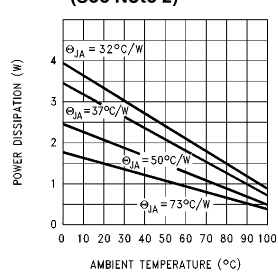




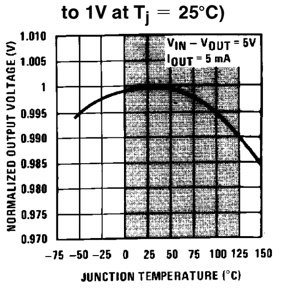
Maximum Average Power Dissipation



Maximum Power Dissipation (TO-263) (See Note 2)

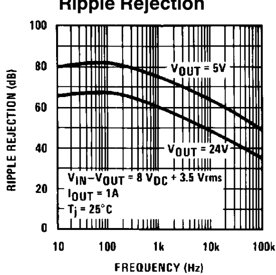


Output Voltage (Normalized to 1V at $T_j = 25°C$)

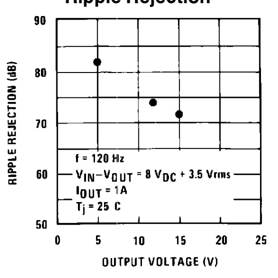


Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

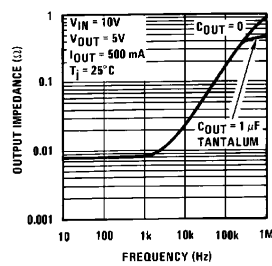
Ripple Rejection



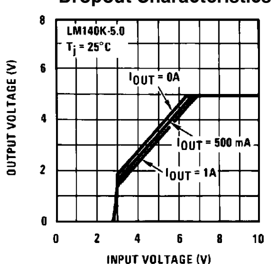
Ripple Rejection



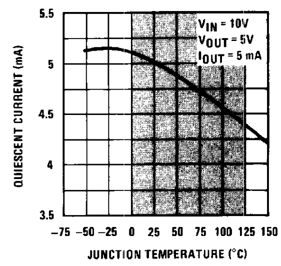
Output Impedance



Dropout Characteristics

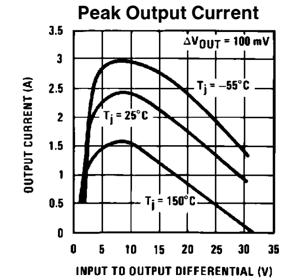


Quiescent Current

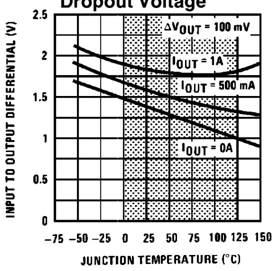


Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Peak Output Current



Dropout Voltage



Note: Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

Quiescent Current

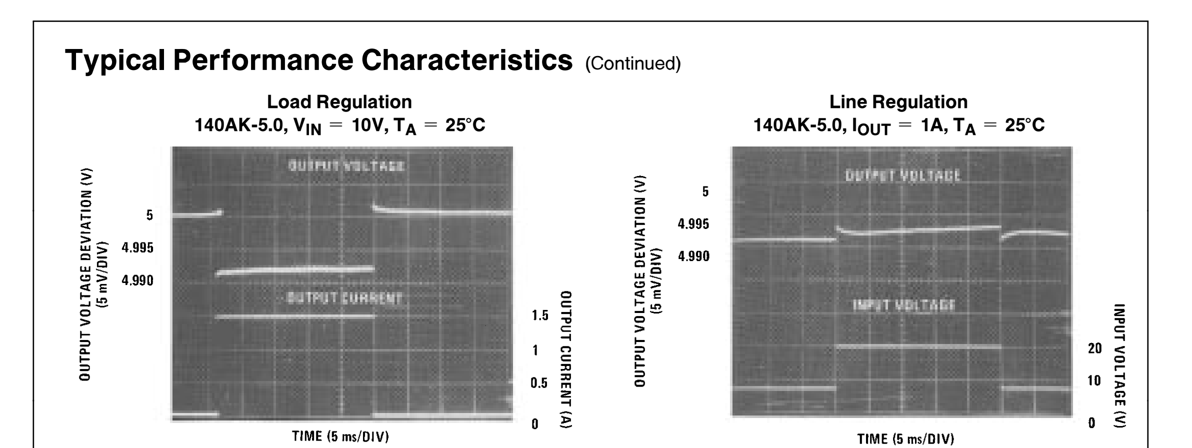
$V_{OUT} = 5V$
$I_{OUT} = 10$ mA
$T_j = 25°C$

QUIESCENT CURRENT (mA)

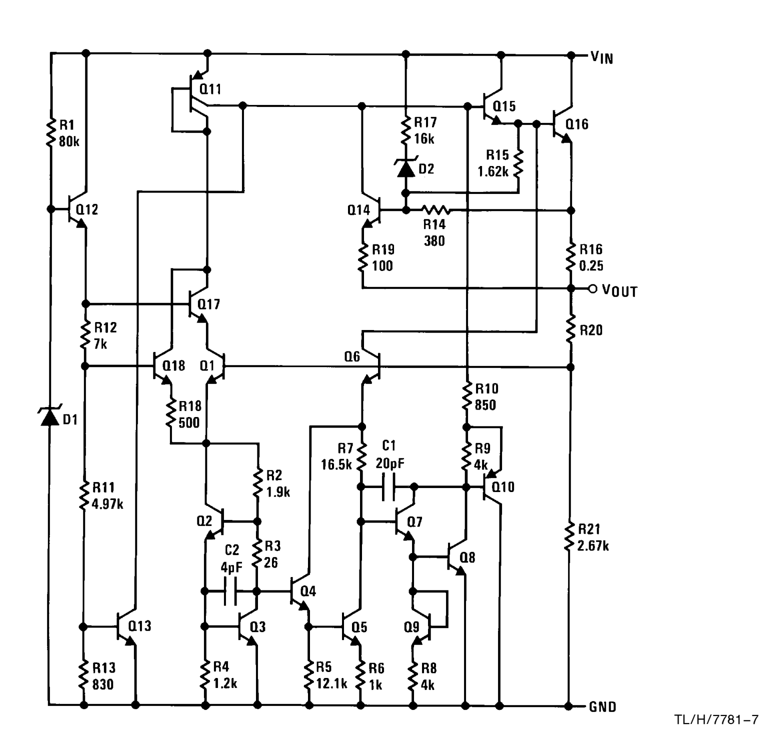
INPUT VOLTAGE (V)

TL/H/7781–4

Typical Performance Characteristics (Continued)



Equivalent Schematic



Application Hints

The LM340/LM78XX series is designed with thermal protection, output short-circuit protection and output transistor safe area protection. However, as with *any* IC regulator, it becomes necessary to take precautions to assure that the regulator is not inadvertently damaged. The following describes possible misapplications and methods to prevent damage to the regulator.

Shorting the Regulator Input: When using large capacitors at the output of these regulators, a protection diode connected input to output *(Figure 1)* may be required if the input is shorted to ground. Without the protection diode, an input short will cause the input to rapidly approach ground potential, while the output remains near the initial V_{OUT} because of the stored charge in the large output capacitor. The capacitor will then discharge through a large internal input to output diode and parasitic transistors. If the energy released by the capacitor is large enough, this diode, low current metal and the regulator will be destroyed. The fast diode in *Figure 1* will shunt most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance $\leq$ 10 μF.

Raising the Output Voltage above the Input Voltage: Since the output of the device does not sink current, forcing the output high can cause damage to internal low current paths in a manner similar to that just described in the "Shorting the Regulator Input" section.

Regulator Floating Ground *(Figure 2)*: When the ground pin alone becomes disconnected, the output approaches the unregulated input, causing possible damage to other circuits connected to V_{OUT}. If ground is reconnected with power "ON", damage may also occur to the regulator. This fault is most likely to occur when plugging in regulators or modules with on card regulators into powered up sockets. Power should be turned off first, thermal limit ceases operating, or ground should be connected first if power must be left on.

Transient Voltages: If transients exceed the maximum rated input voltage of the device, or reach more than 0.8V below ground and have sufficient energy, they will damage the regulator. The solution is to use a large input capacitor, a series input breakdown diode, a choke, a transient suppressor or a combination of these.

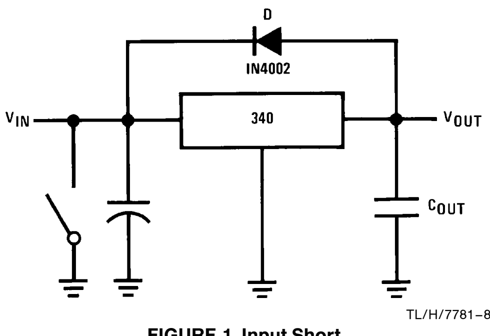


FIGURE 1. Input Short

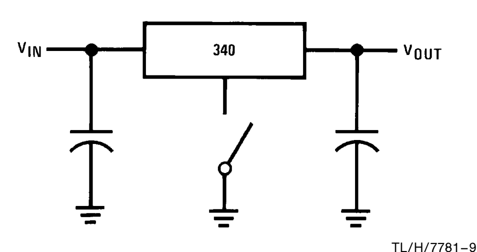


FIGURE 2. Regulator Floating Ground

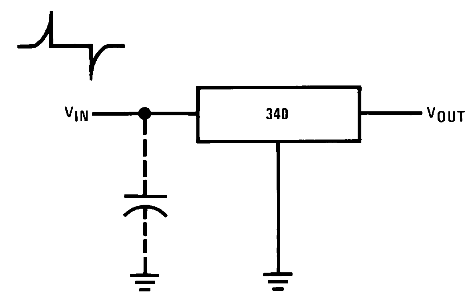


FIGURE 3. Transients

Typical Applications

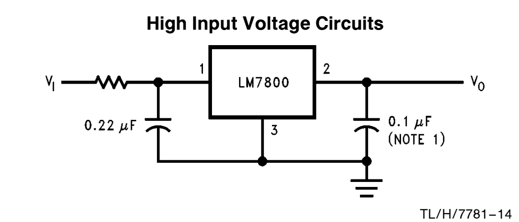
Fixed Output Regulator

V_I 1 LM7800 2 V_O
0.22 μF + 3 + 0.1 μF

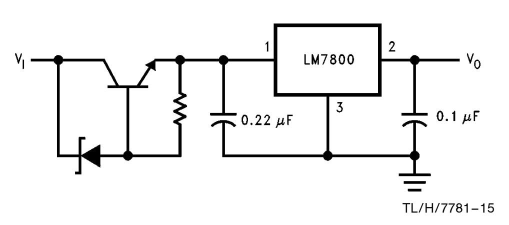
TL/H/7781–13

Note 1: Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

High Input Voltage Circuits

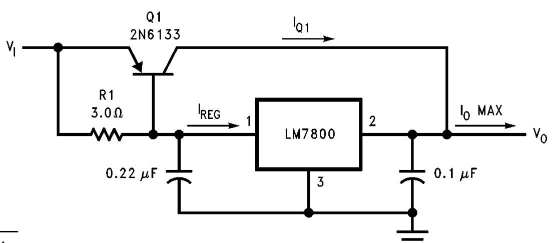


TL/H/7781–14



TL/H/7781–15

High Current Voltage Regulator

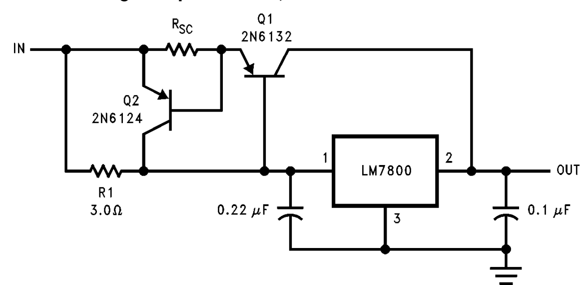


$$\beta(Q1) \geq \frac{I_{O\,Max}}{I_{REG\,Max}}$$

$$R1 = \frac{0.9}{I_{REG}} = \frac{\beta(Q1)\,V_{BE(Q1)}}{I_{REG\,Max}\,(\beta + 1) - I_{O\,Max}}$$

TL/H/7781–16

High Output Current, Short Circuit Protected

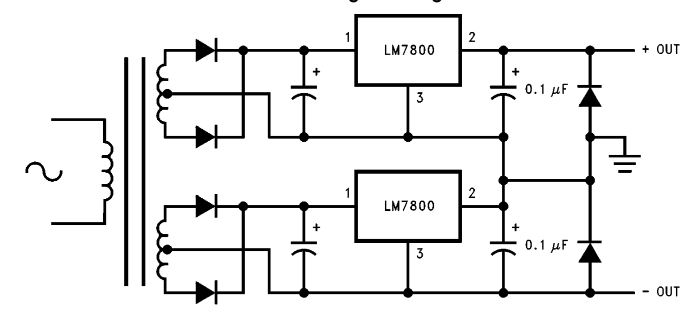


$$R_{SC} = \frac{0.8}{I_{SC}}$$

$$R1 = \frac{\beta V_{BE(Q1)}}{I_{REG\,Max}\,(\beta + 1) - I_{O\,Max}}$$

TL/H/7781–17

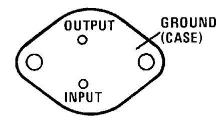
Positive and Negative Regulator



TL/H/7781–18

Connection Diagrams and Ordering Information

TO-3 Metal Can Package (K)



TL/H/7781–11

Bottom View

Steel Package Order Numbers:

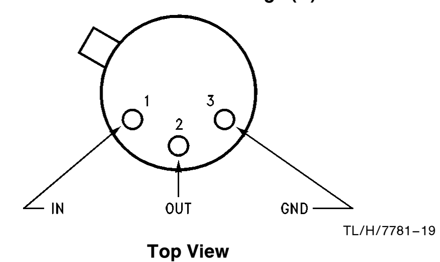
LM140K-5.0	**LM140K-12**	**LM140K-15**
LM340AK-5.0	**LM340K-12**	**LM340K-15**
LM340K-5.0		

See Package Number K02A

LM140AK-5.0/883	**LM140AK-12/883**	**LM140AK-15/883**
LM140K-5.0/883	**LM140K-12/883**	**LM140K-15/883**

See Package Number K02C

TO-39 Metal Can Package (H)



TL/H/7781–19

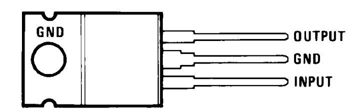
Top View

Metal Can Order Numbers†:

LM140H-5.0/883	**LM140H-6.0/883**
LM140H-8.0/883	**LM140H-12/883**
LM140H-15/883	**LM140H-24/883**

See Package Number H03A

TO-220 Power Package (T)



TL/H/7781–12

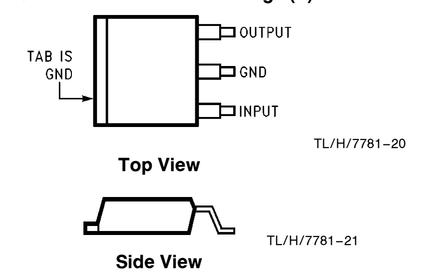
Top View

Plastic Package Order Numbers:

LM340AT-5.0	**LM340T-5.0**
LM340AT-12	**LM340T-12**
LM340AT-15	**LM340T-15**
LM7805CT	**LM7812CT**
LM7815CT	**LM7806CT**
LM7808CT	**LM7818CT**
LM7824CT	

See Package Number T03B

TO-263 Surface-Mount Package (S)



TL/H/7781–20

Top View

TL/H/7781–21

Side View

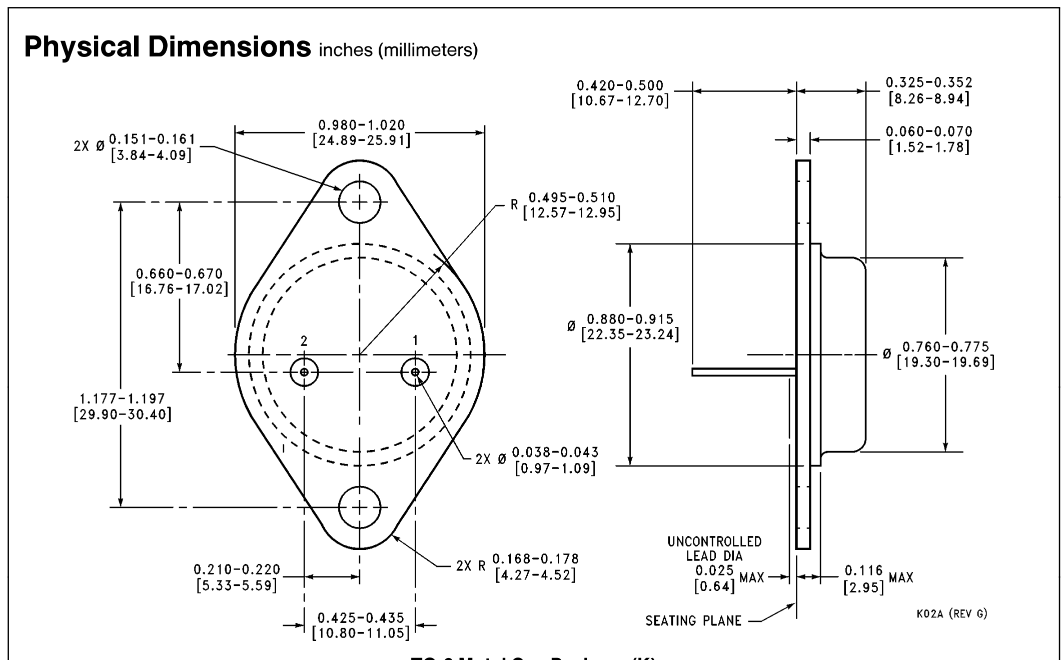
Surface-Mount Package Order Numbers:

LM7805S   LM7812S

See Package Number TS3B

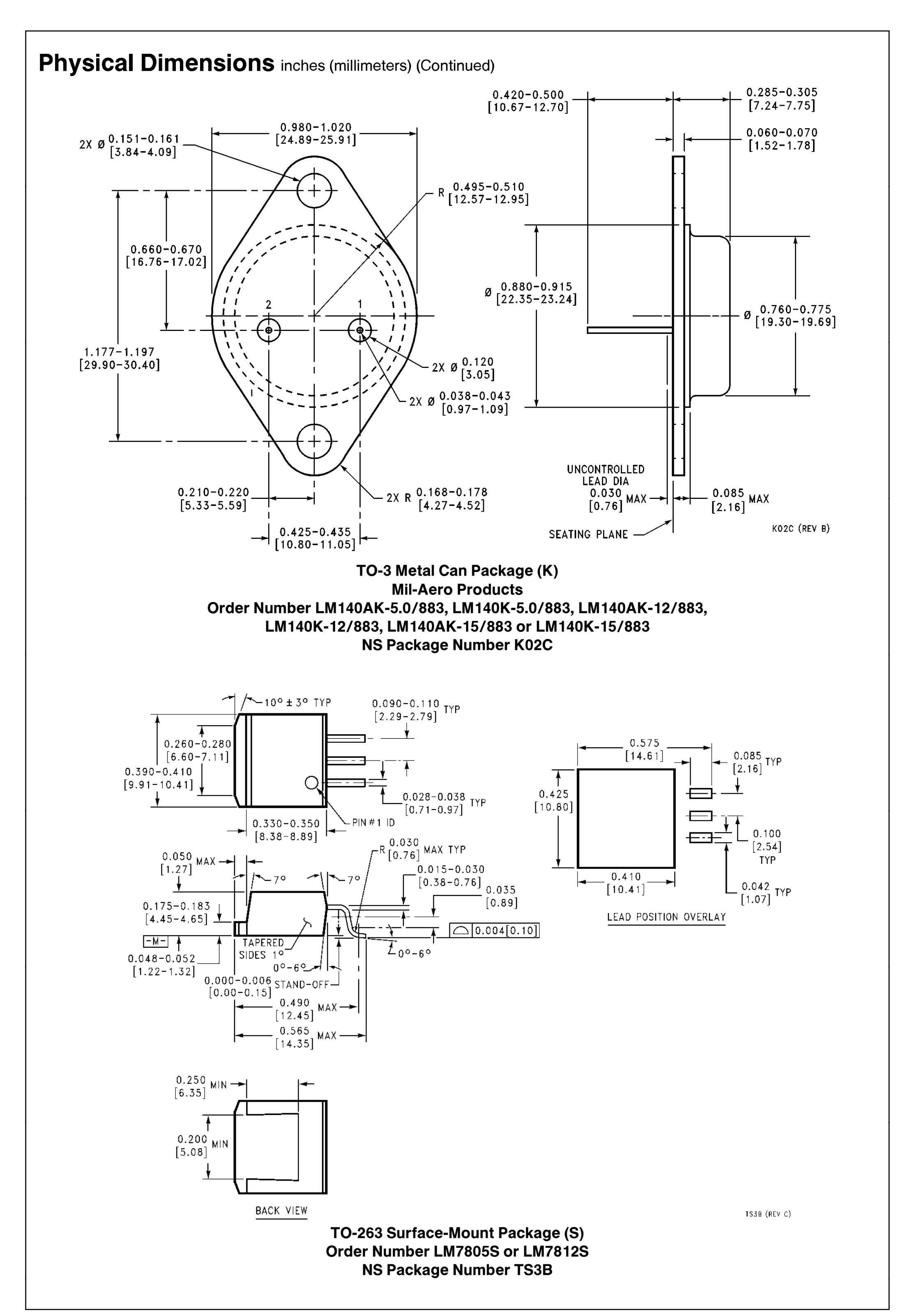
†The specifications for the LM140H/883 devices are not contained in this datasheet. If specifications for these devices are required, contact the National Semiconductor Sales Office/Distributors.

Physical Dimensions inches (millimeters)



TO-3 Metal Can Package (K)
Order Number LM340AK-5.0, LM140K-5.0, LM340K-5.0, LM140K-12, LM340K-12, LM140K-15, LM340K-15, LM7806CK, LM7808CK, LM7818CK or LM7824CK
NS Package Number K02A

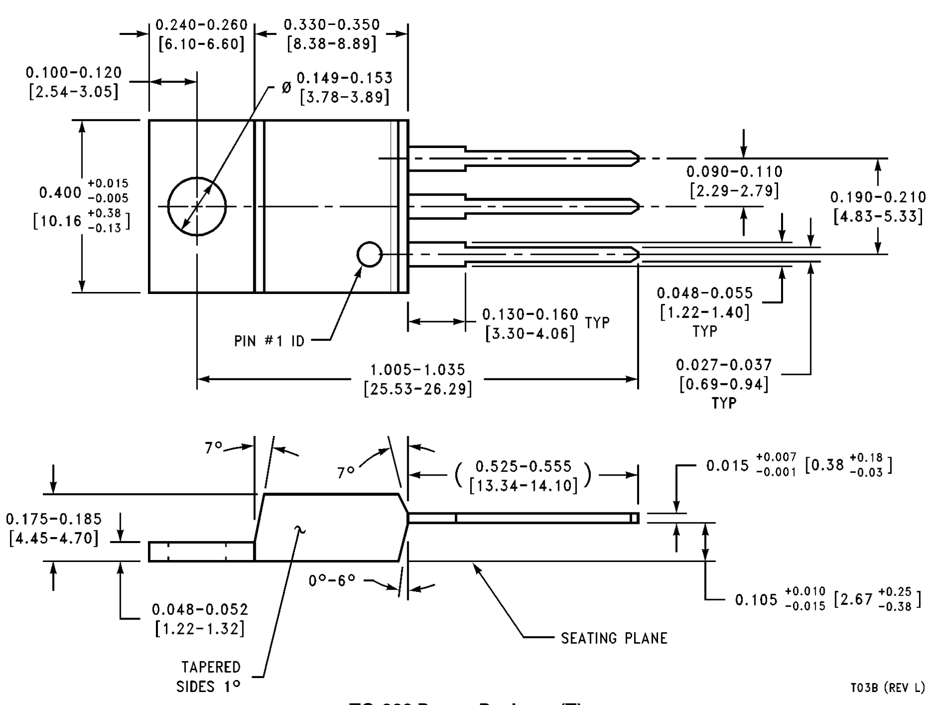
Physical Dimensions inches (millimeters) (Continued)



TO-3 Metal Can Package (K)
Mil-Aero Products
Order Number LM140AK-5.0/883, LM140K-5.0/883, LM140AK-12/883, LM140K-12/883, LM140AK-15/883 or LM140K-15/883
NS Package Number K02C

TO-263 Surface-Mount Package (S)
Order Number LM7805S or LM7812S
NS Package Number TS3B

Physical Dimensions inches (millimeters) (Continued)



TO-220 Power Package (T)
Order Number LM340AT/LM340T-5.0, LM340AT/LM340T-12, LM340AT/LM340T-15, LM7805CT, LM7812CT, LM7815CT, LM7806CT, LM7808CT, LM7818CT or LM7824CT
NS Package Number T03B



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